REMARKS

Claims 1-39 are pending and remain rejected as unpatentable over DiMeo (U.S. Patent No. 5,972,430) in view of Kirlin (U.S. Patent No. 5,453,494) and/or Maita (U.S. Patent No. 6,020,024). As put forth in the Response filed September 23, 2003, Applicants maintain that the Examiner has failed to appreciate that atomic layer epitaxy (ALE) is a term of art which does not encompass prior art CVD processes regardless of whether or not those CVD processes are alternated and/or digital. In addition, the references of record, when combined, do not suggest ALE deposition using one of the claimed cyclopentadienyl precursors. Applicants provide herewith supplemental amendments and remarks with supporting references which further emphasize the distinction between ALE and CVD.

Amendments

Although Applicants believe that the amendments presented in the prior Response place the application in condition for allowance, in order to speed prosecution Applicants have further amended Claims 1, 27, and 28 to recite an ALE process which "achieve[s] film growth through saturating surface reactions." In addition, Applicants have amended Claim 36 to recite employing "saturating, self-limiting surface reactions on the substrate."

The amendments are fully supported by the specification as filed. For example, at page 9, line 6 the application teaches "[s]ince[,] according to the ALE method[,] the film grows through saturating surface reactions, the growth is self-controlling, which in turns ensures excellent conformality."

Distinctions Between CVD and ALE

The digital chemical vapor deposition (digital CVD) method of the primary reference, DiMeo, is fundamentally distinct from atomic layer epitaxy (ALE) (also known as atomic layer deposition or "ALD") with respect to both the means employed and ends achieved. The skilled artisan would recognize these fundamental differences and understand that precursors taught as suitable for CVD are not automatically applicable to ALE, as assumed by the Examiner.

One important distinction between DiMeo's digital CVD and Applicants' claimed ALE method is that the growth rate by ALE is necessarily limited, while the growth rate by CVD can be manipulated by modifying the source chemical dosage. In particular, while the growth rate of digital CVD can vary across a wide range depending on source chemical dosage, the growth rate

for an ALE process is ***self-limited*** to one monolayer or less per cycle by the ***self-saturating surface reactions***. Accordingly, ALE is not sensitive to the dosage of the source chemical. By contrast, digital CVD requires that the source chemical dosage be precisely controlled.

An example of the need for precise control of the source chemical dosage in CVD is taught in DiMeo; "Typically and preferably, the multi-component oxide precursor layer is formed over the substrate 14 to a thickness of from about 5 to about 100 Angstroms ***employing an appropriate precursor reactant source materials flow rate***." Col. 9, lines 34-38 (*emphasis added*). Thus, according to the process disclosed in DiMeo the thickness of the multi-component oxide precursor layer correlates with the precursor reactant source materials flow rate. Contrary to this, in the claimed ALE processes the growth rate is not sensitive to the reactant flow rate because each deposition cycle adds no more than one molecular monolayer of metal oxide to the film thickness through ***saturating surface reactions***. This distinction has been further clarified by amending the independent claims to recite "achieve[ing] film growth through saturating surface reactions" (Claims 1, 27, and 28) and employing "saturating, self-limiting surface reactions on the substrate" (Claim 36).

Further, DiMeo is shown to be a multi-molecular layer deposition by the teaching that "[t]he barium strontium titanate (BST) layers were formed upon the first series of substrates employing the foregoing conditions for a total of 100 cycles, which provided barium strontium titanate (BST) layers of total thicknesses [of] about 3300 Angstroms." Col 12, ll. 53-57. Accordingly, it is clear that DiMeo teaches a method yielding a BST growth rate of 33 Å/cycle (3300 Angstroms per 100 cycles). The thickness of one molecular monolayer of a metal oxide is close to the lattice constant of the metal oxide. For example, the lattice constant of cubic BaO is 4.0 Å and the lattice constants of tetragonal SrO are 3.7 and 4.0 Å (R. Kita et al., J. Mater. Res. 8 (1996) p. 321, copy enclosed). Thus, several molecular monolayers were formed during each cycle on the substrate in DiMeo's process.

In comparison, multiple molecular monolayers are ***not*** formed in an ALE process. Rather, in ALE processes the substrate surface is saturated with ***no more than one molecular monolayer*** of the precursor. What is important is that in an ALE process the thickness of the deposited layer depends on, and is limited by, this saturating surface reaction, which in turn depends on the nature of the source chemicals. In other words, ALE layers can not be deposited

more than one molecular layer at a time because in each reaction cycle when all binding sites for precursor are full, no more precursor is able to bind. In fact, the growth rate in ALE processes is typically less than one molecular monolayer of the compound per cycle, because of bulky source chemical molecules (large ligands, e.g. cyclopentadienyl ligands). Applicants have amended the claims to clearly recite saturating surface reactions. In comparison, CVD processes, such as DiMeo's, are not limited by saturating surface reactions and the requirements for the source chemicals are necessarily different.

In view of the above, it is clear that the digital CVD method of the primary reference, DiMeo, is fundamentally different from atomic layer epitaxy (ALE) with respect to both the means employed and ends achieved. The skilled artisan would recognize the fundamental differences and realize that these disparate methods are not automatically combinable or interchangeable.

To clarify these issues further, we enclose two articles that teach the specific features of ALD deposition and Digital CVD, respectively:

1. M. Vehkamäki et al. have measured the ALD (ALE) growth rates of $SrTiO_3$ and $BaTiO_3$. Electrochemical and Solid-State Letters, 2, pp. 504-506 (1999).

2. M. Nakano et al. have studied the deposition of SiO_2 by digital chemical vapor deposition. Appl. Phys. Lett., 57, pp. 1096-1098 (1990).

In Vehkamäki, the growth rate of $SrTiO_3$ by ALE was shown to be 0.7 – 1.8 Å/cycle depending on the Sr/Ti cycle ratio, while the growth rate of $BaTiO_3$ was 0.5 Å/cycle. These measurements are equivalent to one monolayer of the compound per cycle and are representative of an ALE process.

In comparison, the teachings in Nakano of a digital CVD method are representative of the inherent qualities of CVD. In the abstract, Nakano teaches that "[t]he repetitive cycles of a few monolayers hydrogenated silicon deposition and its oxidation has been employed for the growth of SiO_2." The growth rate of a few monolayers per cycle means that digital chemical vapor deposition is ***not*** based on self-saturating surface reactions.

Nakano also teaches "[a]t the present stage, SiO_2 could not be filled in trenches with aspect ratios larger than 3." Nakano at p. 1097. This indicates that digital chemical vapor deposition is not capable of growing film in relatively deep trenches. In comparison, ALE can advantageously grow thin films in deep trenches because the alternate, self-saturating surface reactions produce conformal films.

Another inherent property of digital CVD is illustrated by Nakano's teaching that "[t]he deposition rate of 3 Å/pulse is achieved by controlling the flow velocity of the SiH_4 gas jet and the pulse width of the O_2 radicals." Nakano at p. 1098. Thus, Nakano confirms DiMeo's teaching that deposition rate in CVD depends on precursor flow rate.

In view of Nakano's teachings, it is clear that digital chemical vapor deposition processes (*e.g.*, the digital CVD process of DiMeo) have different requirements than ALE processes. Digital chemical vapor deposition requires controlling the dosage of the source chemicals in order to achieve a thin film of the desired thickness. Contrary to this, ALE process are not sensitive to the dosage of the source chemical because of the self-saturating nature of the surface reactions. One of skill in the art will recognize that these different requirements will necessarily mean that not all source chemicals employed for CVD will be suited for ALE processes.

No Motivation to Employ DiMeo's Precursors for ALE

In view of the prior Response and Amendment as supplemented by the foregoing amendments, arguments and supporting references, it is clear that DiMeo's digital CVD is fundamentally distinct from the ALE process claimed by Applicants. In light of these distinctions and a lack of a suggestion to combine the cited CVD and ALE references, it is clear that the Examiner has improperly concluded that precursors taught as suitable for CVD are automatically applicable to ALE.

The mere citation of two unrelated passages from within DiMeo does not meet the Examiners burden of showing motivation to modify or combine. Instead, the Examiner must show both the desirability of a particular combination and an expectation that the combination will succeed. This the Examiner has failed to do. In fact, the Examiner's unsupported assumption that CVD is equivalent to ALE runs contrary to the skilled artisans understanding of ALE and CVD, as evidenced by the references provided herewith. *See, generally*, M.

Vehkamäki et al. and M. Nakano et al.; *See, also,* Bedair, S.M., "Atomic layer epitaxy deposition processes," Journal of Vacuum Science Technology B, 12 (1), pp. 179-185, 179 (Jan/Feb 1994).

The Examiner's assertion that precursors that work in CVD will also work in ALE is clearly erroneous and without support. The above discussion clearly demonstrates that ALE is ***not*** a subset or equivalent of CVD. To the contrary, ALE and CVD employ different mechanisms and therefore have different requirements. Because of their different requirements not all CVD precursors will work in an ALE method. With respect to the present application, the characteristics of an ALE mechanism which distinguish it from a CVD mechanism are ***positively recited*** in the claims.

Finally, the Examiner has provided no evidence that the skilled artisan would expect the compounds disclosed in DiMeo to work in an ALE process. Even if it were obvious to try the CVD precursors in ALE reactions, this can not serve as a basis for a rejection under 35 U.S.C. §103. An "obvious to try" standard has been rejected by the Federal Circuit. *See e.g.*, *In re* O'Farrell, 7 U.S.P.Q.2d 1673 (Fed. Cir. 1998). Instead of merely showing it is obvious to try a combination, the Examiner must show both motivation and an expectation of success by the skilled artisan at the time of the invention. Here, the Examiner has provided no motivation to combine the cited teachings and has provided no evidence of an expectation of success. As a result, Applicants submit that the rejections are inappropriate and should be withdrawn.

Conclusion

In view of the foregoing amendments and remarks, Applicants request reconsideration of the rejections and respectfully submit that the claims are in condition for allowance. If, however, some issue remains that the Examiner feels can be addressed by Examiner's Amendment, the Examiner is cordially invited to call the undersigned for authorization.

Please charge any additional fees, including any fees for additional extension of time, or

credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

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